The Resolving Power of LISA:

comparing techniques for binary analysis

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THE STORYLINE

- Metrics for binary analysis techniques
- "Resolving power"
- gCLEAN & MaxEnt

What to tell your mom you learned at LISA 6

- Comparing different techniques is *hard*! (cf. Larson & Hellings talks; *Globular Clusters and Gravitational Waves* at Penn State, Oct 2003).
  - ▷ Making techniques talk to each other
  - ▷ Making answers which *can* be compared
  - ▷ Deciding *what* to compare
- There is no obvious or definitive metric of comparison between analysis techniques (see also WG 1b)
- Good metrics are motivated by the science of interest, not what different techniques are good at. *When do different techniques get similar answers? When do different techniques get different answers?*
- Metrics do not have to involve getting *right* answers, since this is a slippery concept (cf. Neil Cornish's talk, this Symposium)

Techniques for finding binaries

- Many techniques for searching for binaries have been developed
  - ▷ gCLEAN, gCLEAN2 (Cornish & Larson)
  - ▷ Maximum likelihood (Tinto & Krolak)
  - ▷ Tomographic Mapping (Mohanty & Nayak)
  - ▷ Markov Chain Monte Carlo (Umstatter et al.; Wickham et al.; Cornish et al.)
  - ▷ Genetic Algorithms (Crowder & Cornish)
  - ▷ Slice & Dice (Rubbo et al.)
  - ▷ MaxEnt (Finn)
- Most in the literature, and initial studies have been performed
- What can be done to directly *compare techniques*?

Defining a ‘metric’ of comparison

- No single technique will be the hammer for every data analysis nail.
- Ask the *same questions* of different techniques for the purpose of assessing their relative strengths
  - ▷ When should I choose to work with one technique over another?
  - ▷ When should I work with both techniques to check each other?
  - ▷ When should I work with both techniques to support each other?

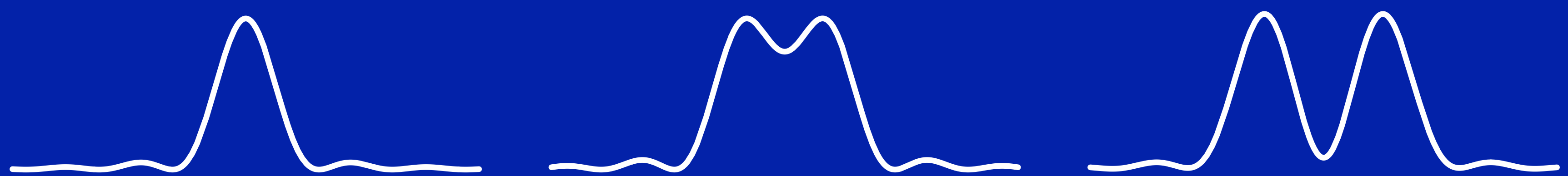
Ideal conditions for a study

- *Common data sets*
  - ▷ Same sources, same noise, same LISA configuration
  - ▷ Common data sets are becoming available (cf. TLA, WG1b Challenge data)
- Not all techniques are ready to work with common data
  - ▷ Homegrown input formats (largely mitigated by provided software)
  - ▷ Single data channels or specific TDI channels
  - ▷ Built in models of LISA response and LISA ephemeris
- Barring identical data streams, settle for “identical sources” with similar SNRs, similar LISA configurations.

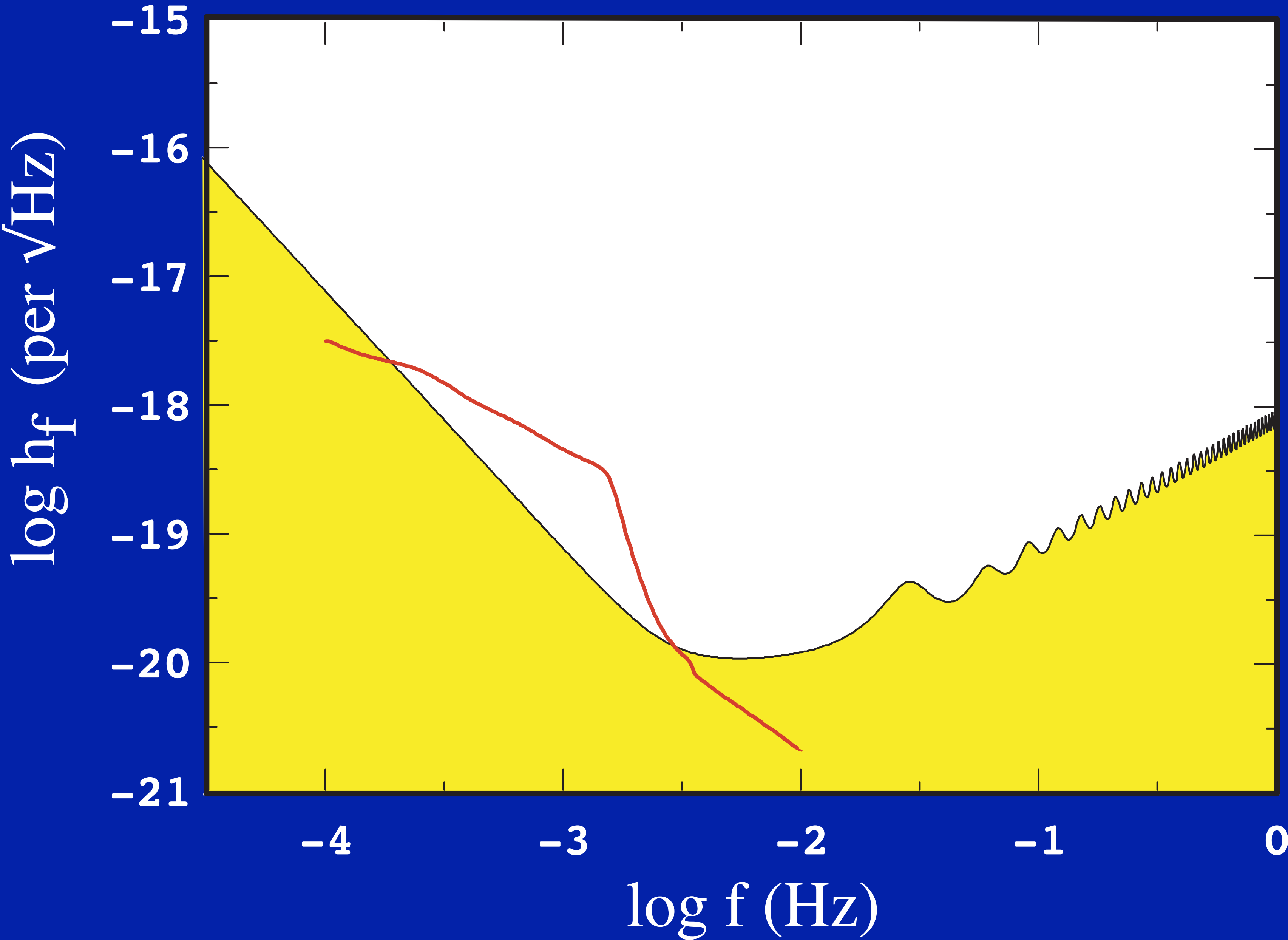
What do we mean: "resolving power"?

- SCIENCE: We are ultimately interested in confusion, and the emergence of confusion, so a metric to consider is "resolving power"
- Most familiar notion about describing telescopic "resolving power" is probably the *Rayleigh criterion*:

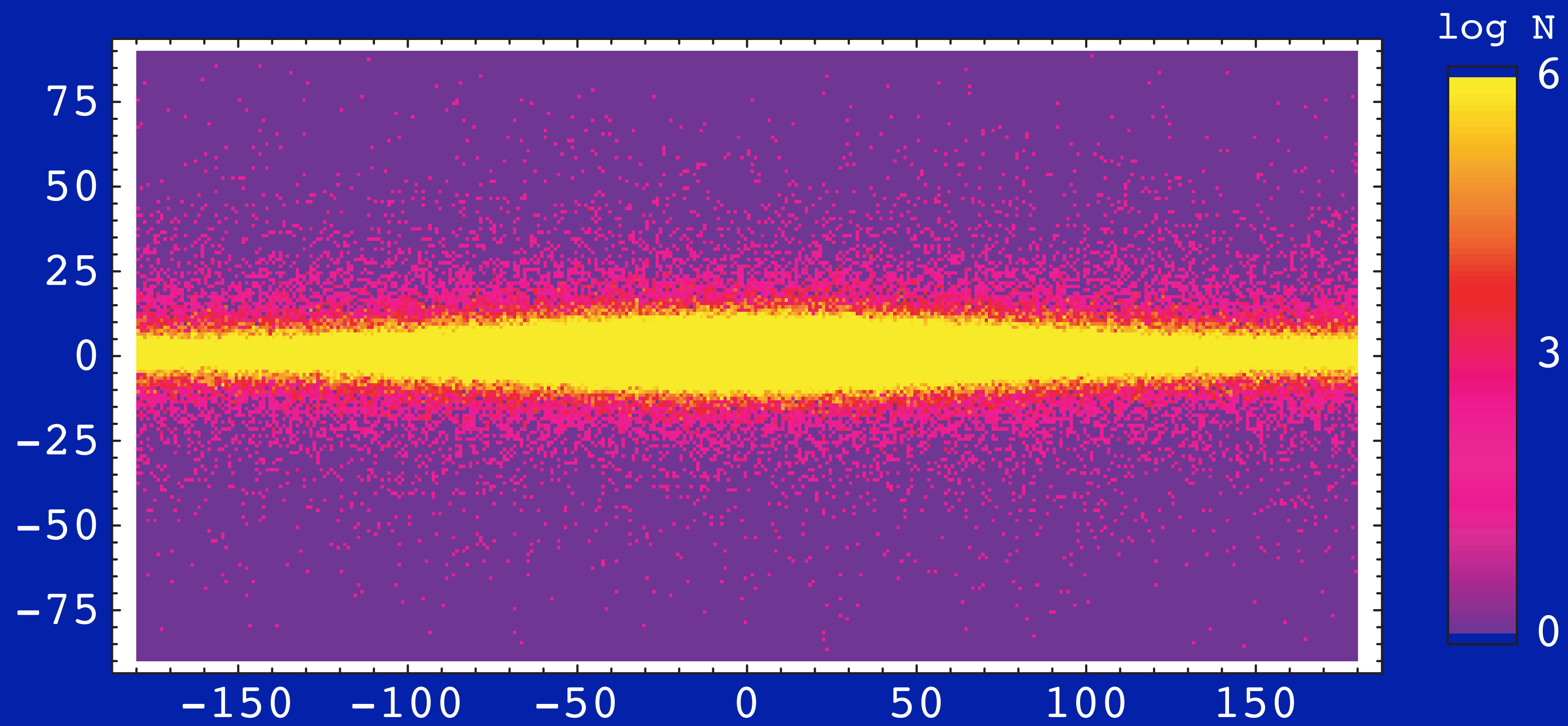
$$\theta = 1.22\ \frac{\lambda}{D}$$



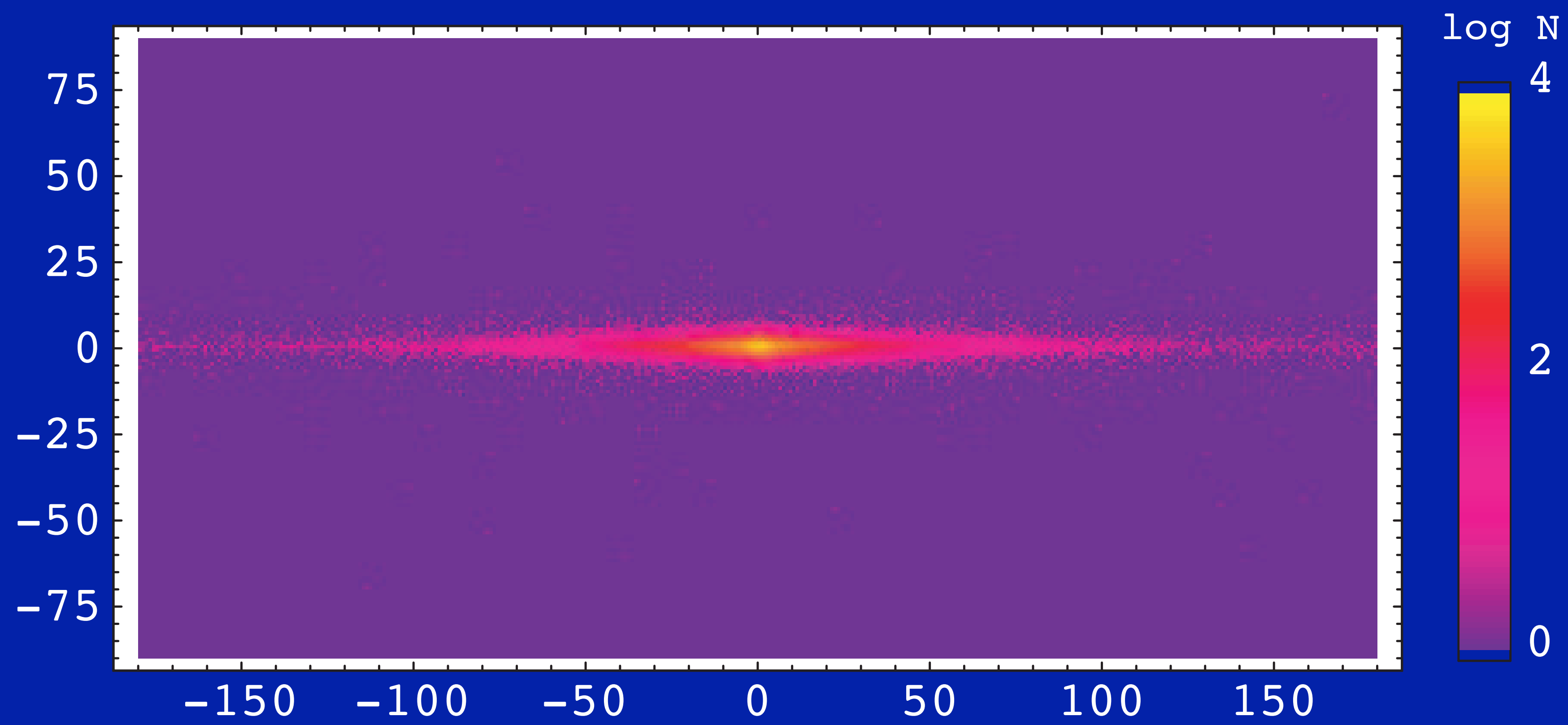
- *Resolving* means "when can I tell the difference between having one source and two?"



−15
−16
−17
−18
−19
−20
−21
log h_f (per √Hz)
−4
−3
−2
−1
0
log f (Hz)



Larson, Benacquista & Taylor (in prep)



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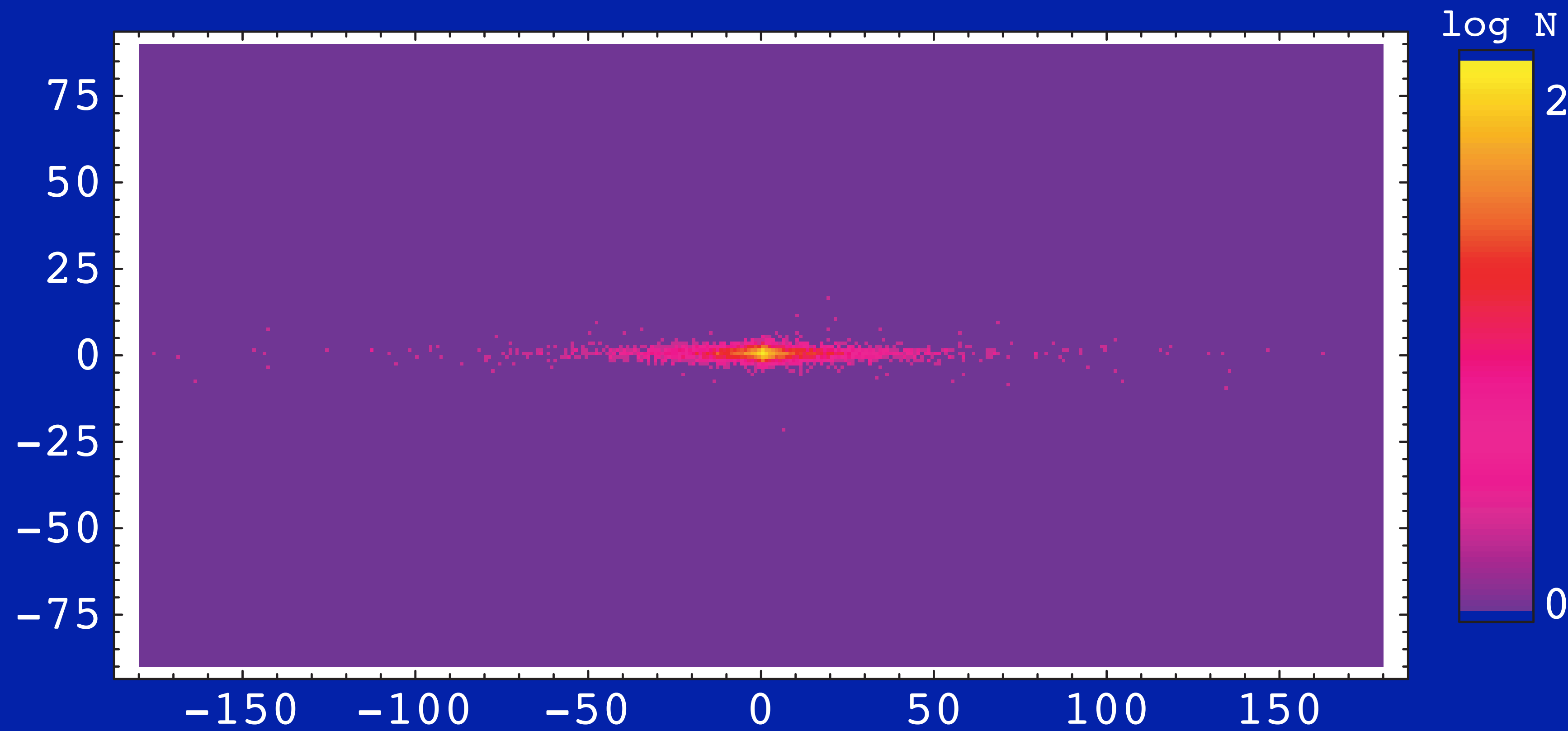

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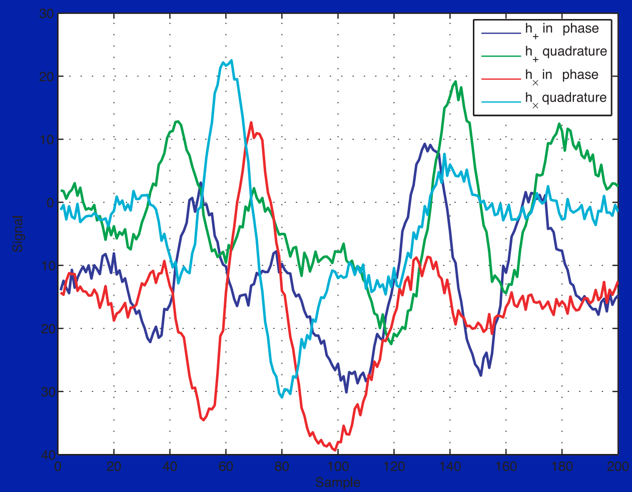
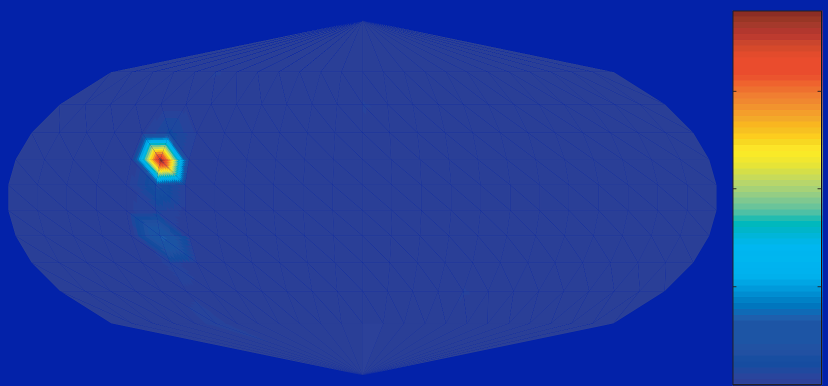
Initial Study Space

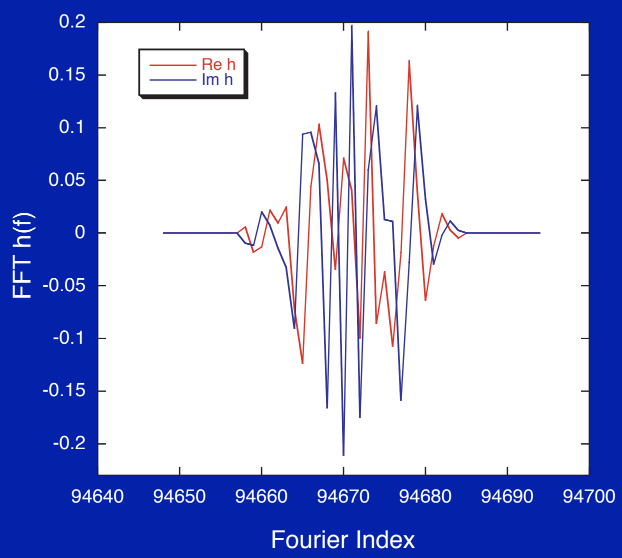
- Data sets have *only 2 binaries*; most of the parameters are *identical*
- Fix all the binary parameters, and vary the sky position. At each step, consider *how many sources does the technique find with SNR* $\gtrsim 5$?
- Default fixed values:
  $\theta = +20°, \phi = 25°, \iota = 70.98°, \psi = 140.95°, \phi_o = 120.68°$

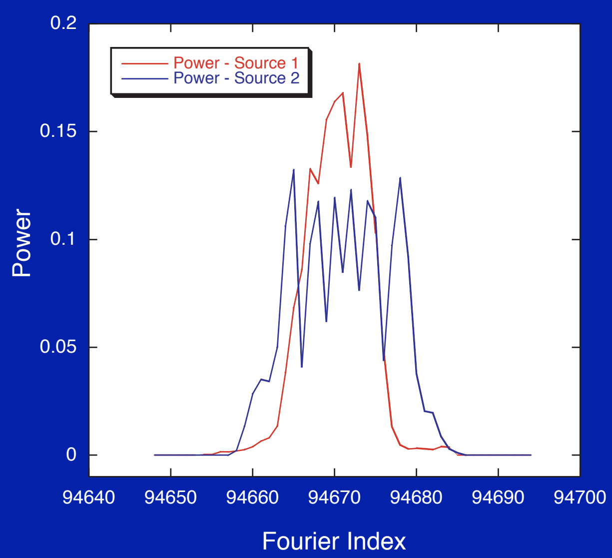
Study	**Fixed Params**	**Varied Params**
1: Latitude Spread	$f, \theta_1, \phi, \psi, \iota, \phi_o, \mathcal{A}$	θ_2
2: Longitude Spread	$f, \theta, \phi_1, \psi, \iota, \phi_o, \mathcal{A}$	ϕ_2
3: Frequency Spread	$f_1, \theta, \phi, \psi, \iota, \phi_o, \mathcal{A}$	f_2

What do we mean: “comparison is hard”?

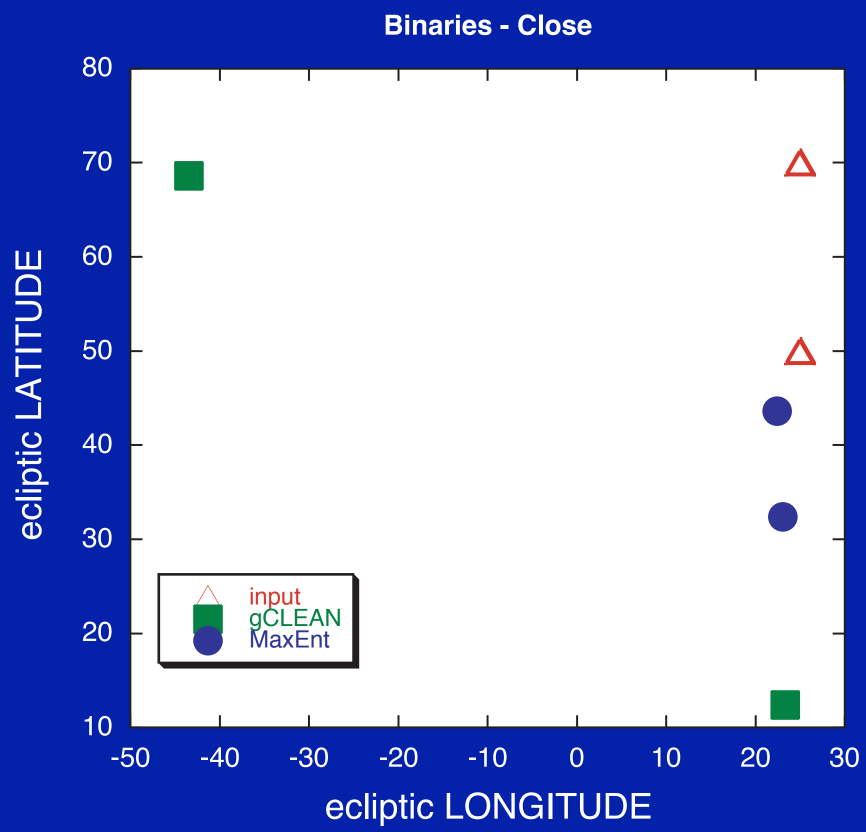


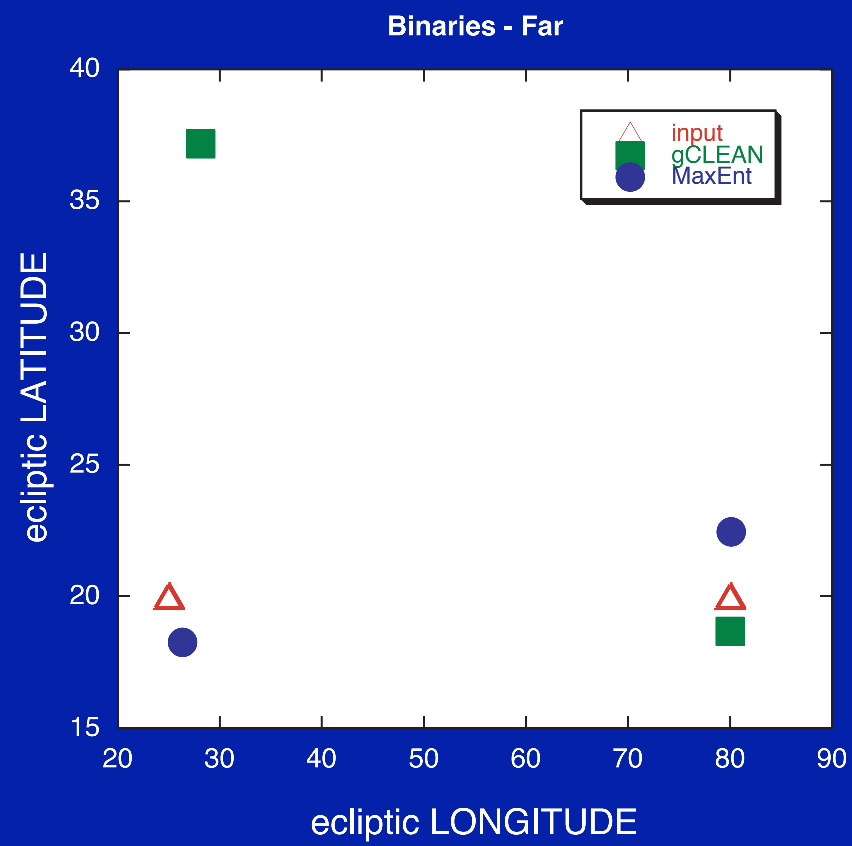






Two resolution examples. . .





SUMMARY

- Devising methods of comparison between different techniques
- What can we do with each technique, and how do their capabilities complement each other to return the best science from LISA.
- No technique will be the only technique to use. *Every technique will have its strengths and weaknesses, which we should exploit.*

“We’re groping among answers for the question.”
– Sam Finn